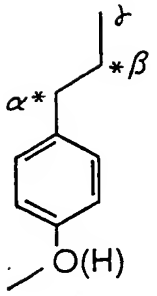


FIG.1

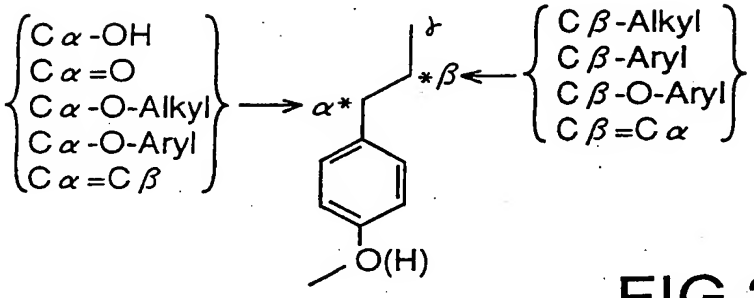


FIG.2

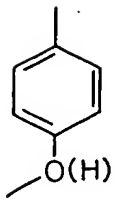


FIG.3 (a)

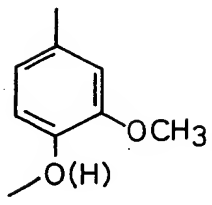


FIG.3 (b)

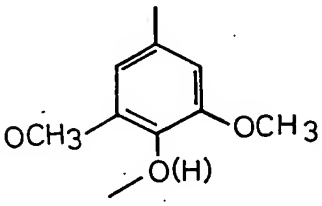


FIG.3 (c)

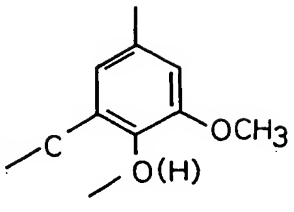


FIG.3 (d)

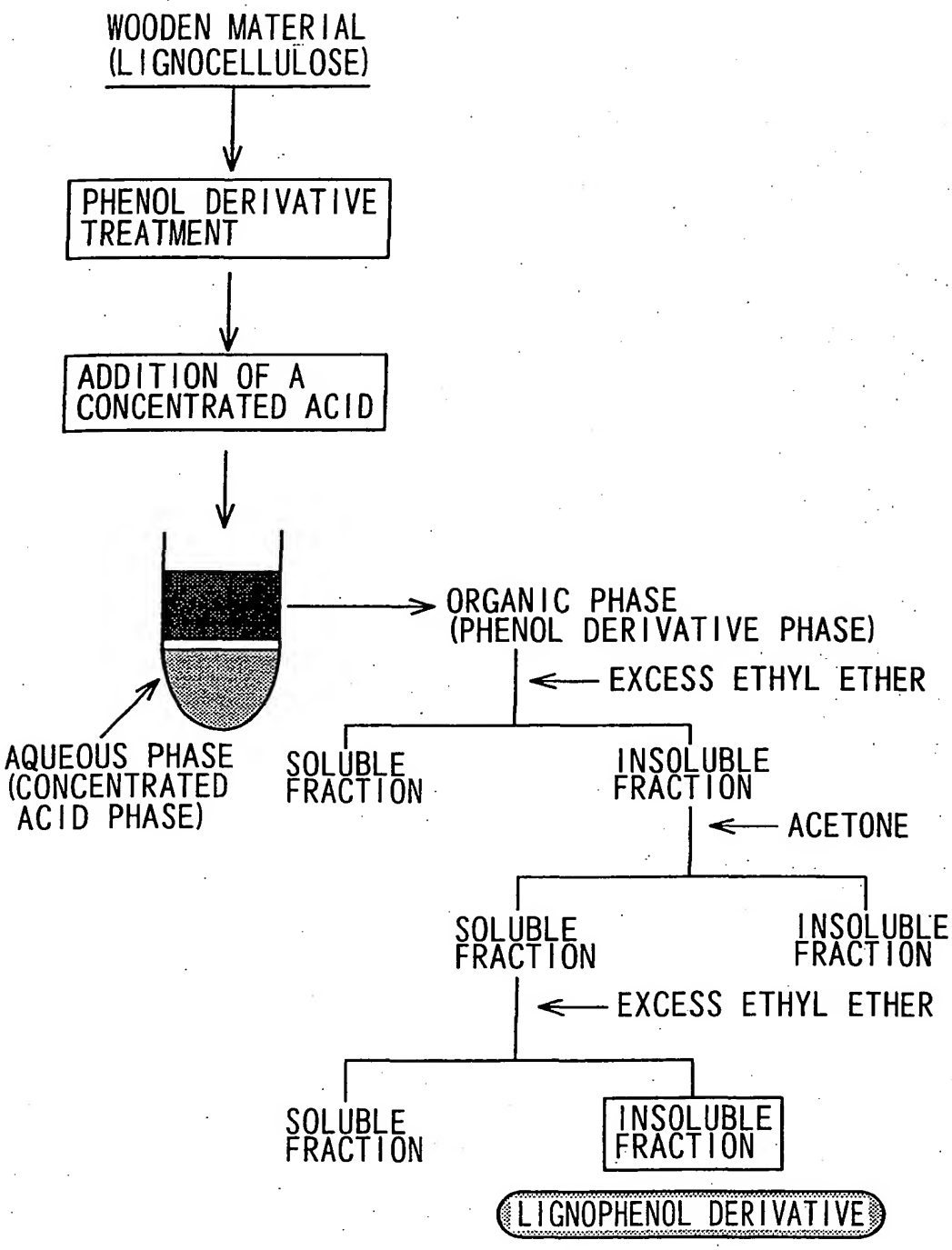

WOODEN MATERIAL
(LIGNOCELLULOSE)
PHENOL DERIVATIVE TREATMENT
ADDITION OF A CONCENTRATED ACID
ORGANIC PHASE
(PHENOL DERIVATIVE PHASE)
EXCESS ETHYL ETHER
AQUEOUS PHASE
(CONCENTRATED ACID PHASE)
SOLUBLE FRACTION
INSOLUBLE FRACTION
ACETONE
SOLUBLE FRACTION
INSOLUBLE FRACTION
EXCESS ETHYL ETHER
SOLUBLE FRACTION
INSOLUBLE FRACTION
LIGNOPHENOL DERIVATIVE

FIG.4

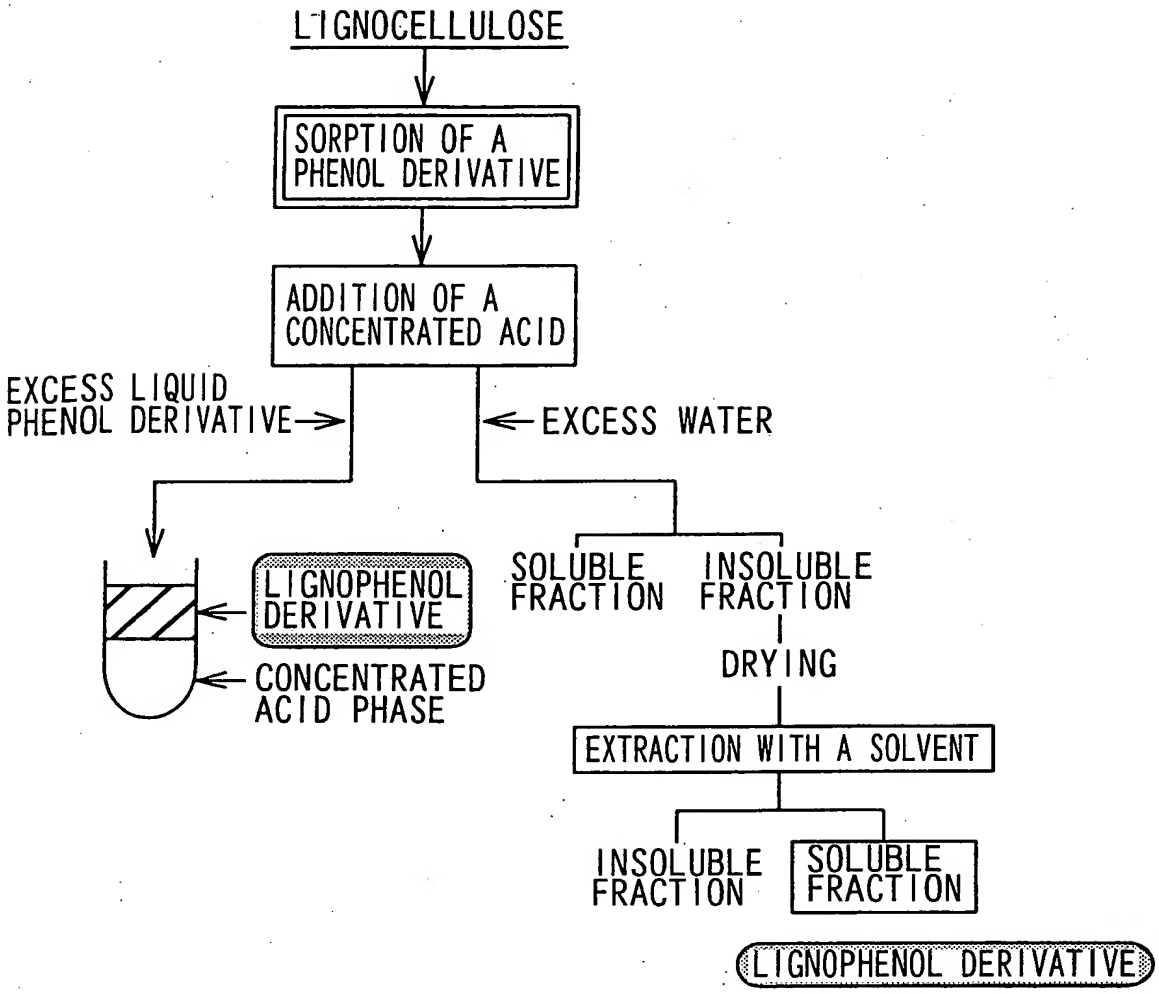

LIGNOCELLULOSE
SORPTION OF A PHENOL DERIVATIVE
ADDITION OF A CONCENTRATED ACID
EXCESS LIQUID PHENOL DERIVATIVE
EXCESS WATER
LIGNOPHENOL DERIVATIVE
CONCENTRATED ACID PHASE
SOLUBLE FRACTION
INSOLUBLE FRACTION
DRYING
EXTRACTION WITH A SOLVENT
INSOLUBLE FRACTION
SOLUBLE FRACTION
LIGNOPHENOL DERIVATIVE

FIG.5

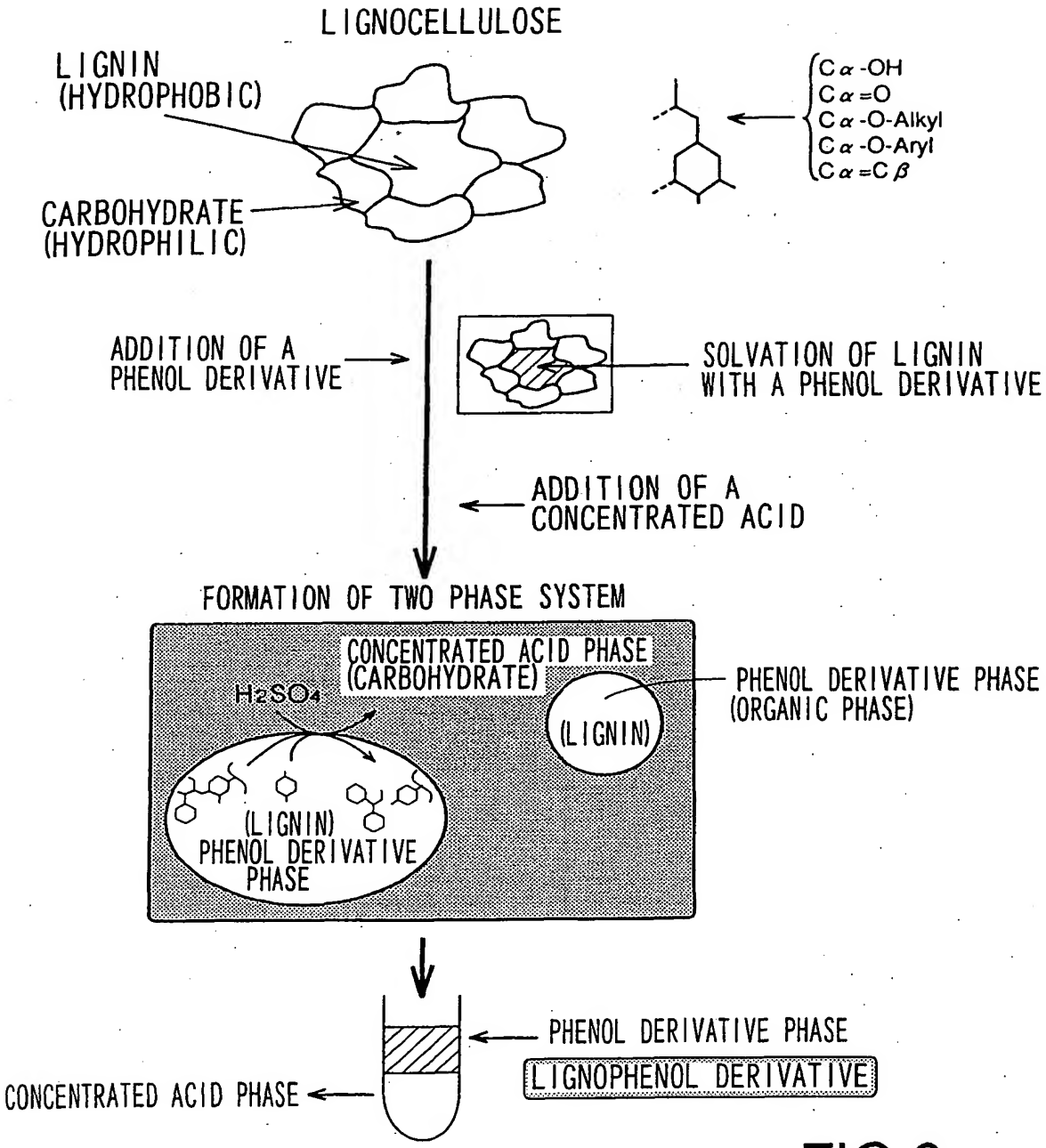

LIGNOCELLULOSE
LIGNIN
(HYDROPHOBIC)
CARBOHYDRATE
(HYDROPHILIC)
Cα-OH
Cα=O
Cα-O-Alkyl
Cα-O-Aryl
Cα=Cβ
ADDITION OF A
PHENOL DERIVATIVE
SOLVATION OF LIGNIN
WITH A PHENOL DERIVATIVE
ADDITION OF A
CONCENTRATED ACID
FORMATION OF TWO PHASE SYSTEM
CONCENTRATED ACID PHASE
(CARBOHYDRATE)
H2SO4
(LIGNIN)
PHENOL DERIVATIVE PHASE
(ORGANIC PHASE)
(LIGNIN)
PHENOL DERIVATIVE
PHASE
PHENOL DERIVATIVE PHASE
LIGNOPHENOL DERIVATIVE
CONCENTRATED ACID PHASE

FIG.6

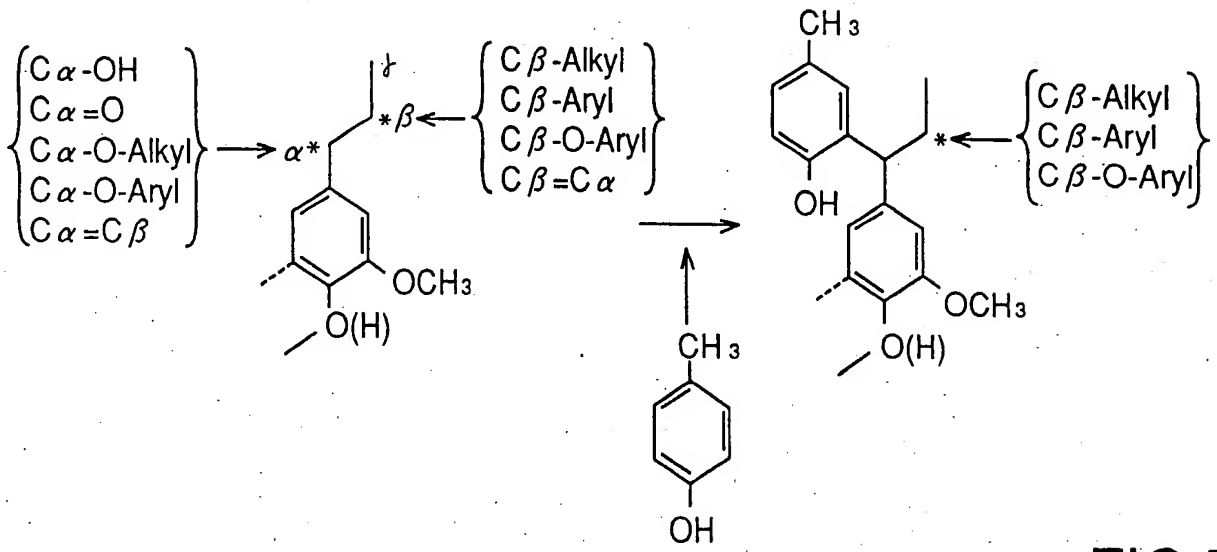

Cα-OH
Cα=O
Cα-O-Alkyl
Cα-O-Aryl
Cα=Cβ
α*
γ
*β
Cβ-Alkyl
Cβ-Aryl
Cβ-O-Aryl
Cβ=Cα
OCH3
O(H)
CH3
OH
CH3
OH
OCH3
O(H)
Cβ-Alkyl
Cβ-Aryl
Cβ-O-Aryl
*

FIG.7

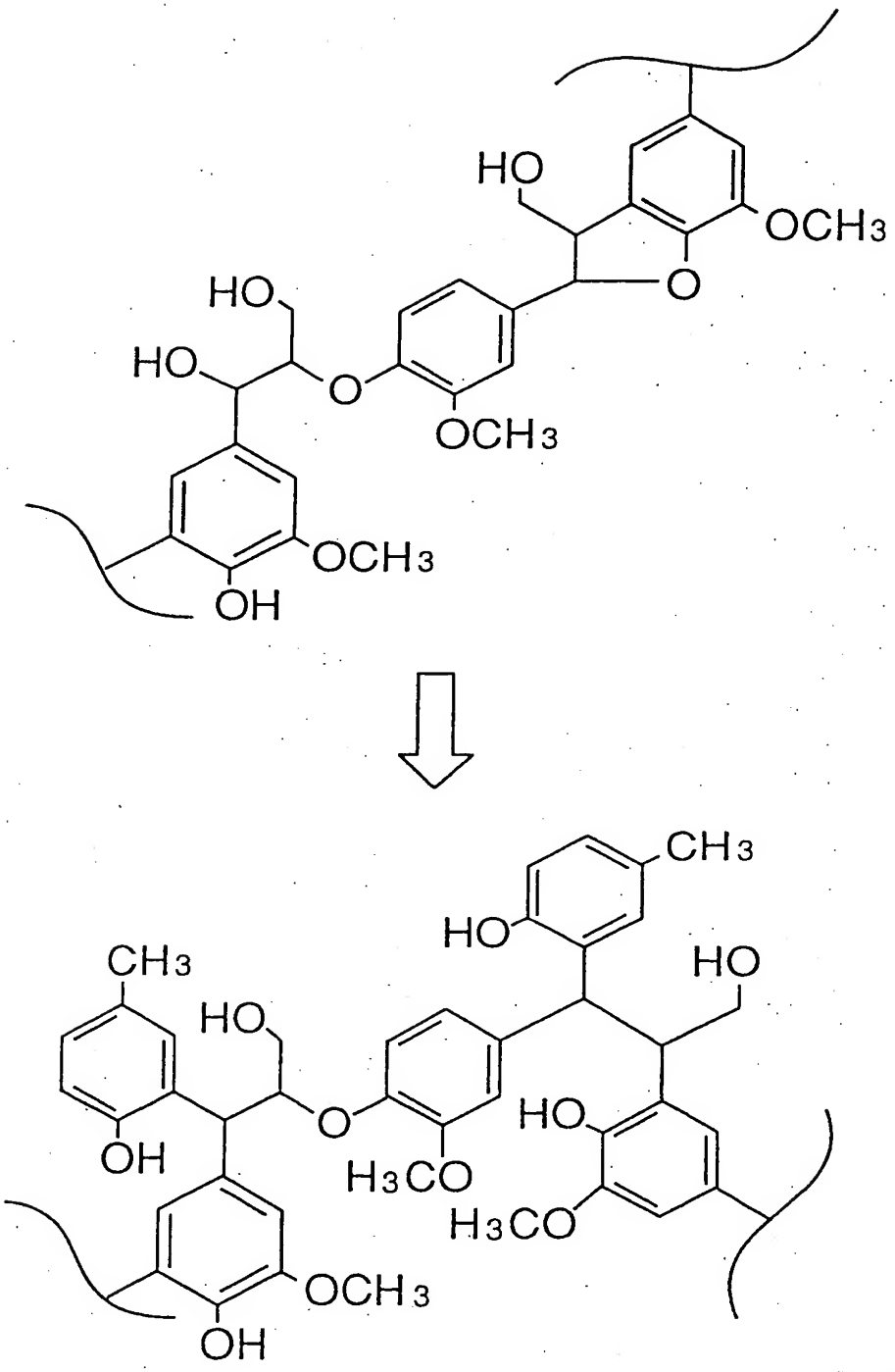

HO
OCH3
HO
HO
O
O
OCH3
OCH3
OH
CH3
HO
HO
CH3
HO
OH
O
HO
H3CO
H3CO
OCH3
OH

FIG.8

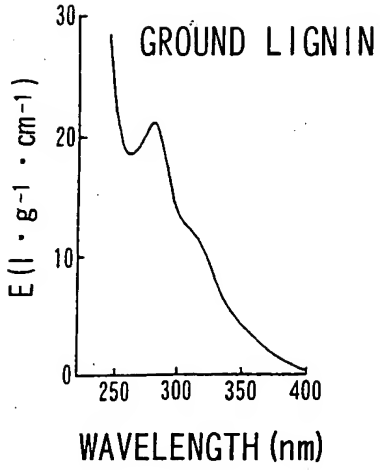


FIG.9 (a)

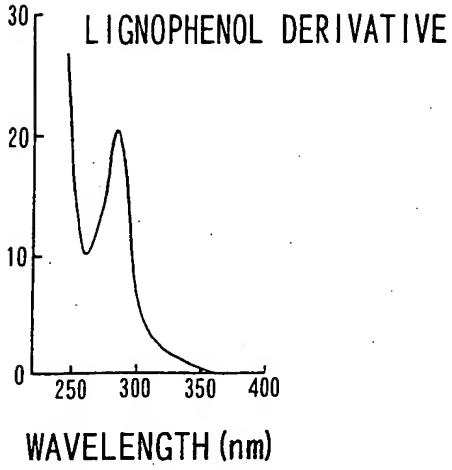


FIG.9 (b)

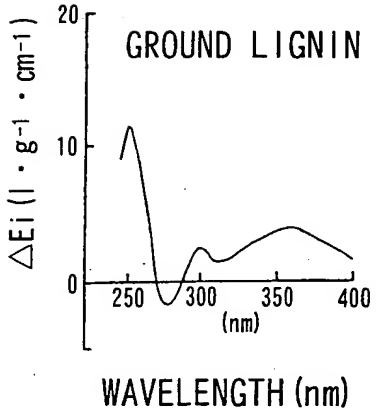


FIG.10 (a)

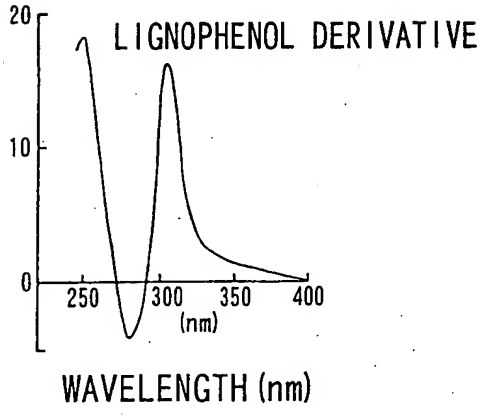


FIG.10 (b)

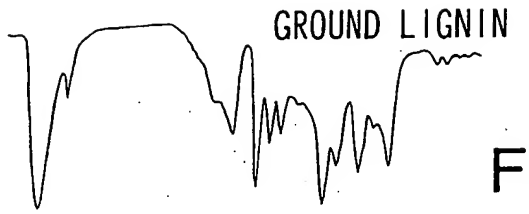


FIG.11 (a)

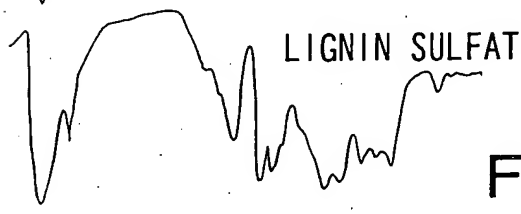


FIG.11 (b)

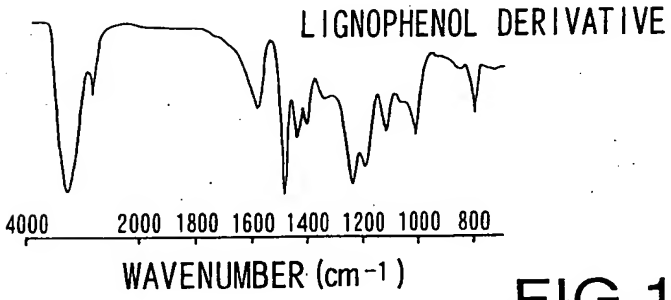


FIG.11(c)

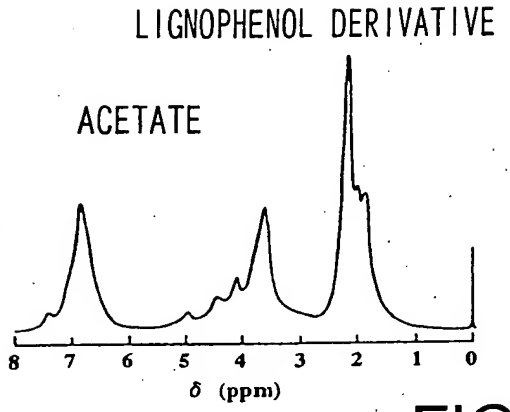


FIG.12 (a)

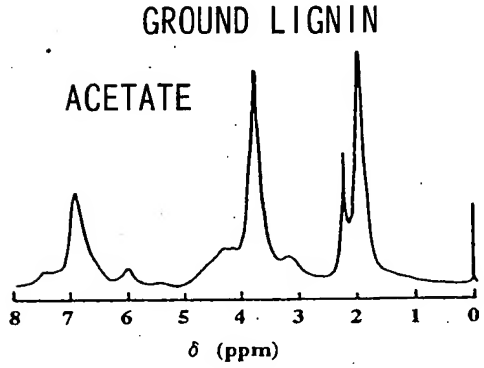


FIG.12 (b)

SAMPLE		YIELD (% of Klason lignin)
Yezo spruce	(*Picea jezoensis*)	108.2
Japanese fir	(*Abies firma*)	111.8
Japanese cedar	(*Cryptomeria japonica*)	110.3
Japanese birch	(*Betula platyphylla*)	103.0
Japanese oak	(*Quercus mongolica*)	109.3
Apitong	(*Dipterocarpus grandiflorus*)	101.6

FIG.13

SAMPLE	ELEMENTARY ANALYSIS RESULTS C	H	O	INTRODUCED CRESOL %	mol/C9	APPEARANCE	DISSOLVING SOLVENT
GROUND LIGNIN							
Yezo spruce (*Picea jezoensis*)	61.5	5.8	32.7				
LIGNOPHENOL DERIVATIVE							
Yezo spruce (*Picea jezoensis*)	66.8	6.0	27.2	25.9	0.65		
Japanese fir (*Abies firma*)	66.5	5.8	27.7	25.0	0.62	Light pink	Methanol
Japanese cedar (*Cryptomeria japonica*)	66.2	5.9	27.9	24.8	0.62		Ethanol
							Acetone
Japanese birch (*Betula platyphylla*)	59.7	6.1	34.2				Dioxane
							THF
							Pyridine
							DMF
Japanese birch (*Betula platyphylla*)	64.3	6.0	29.7	30.9	0.90		etc.
Japanese oak (*Quercus mongolica*)	65.0	6.1	28.9	26.0	0.81	Light pink	
Apitong (*Dipterocarpus grandiflorus*)	67.9	6.1	26.0	33.2	0.92		

FIG.14

SAMPLE	HYDROXYL GROUP (mol/C9)		
	C_α	C_γ	Phenolic
GROUND LIGNIN			
Yezo spruce (*Picea jezoensis*)	0.35	0.80	0.35
LIGNOPHENOL DERIVATIVE			
Yezo spruce (*Picea jezoensis*)	Trace	0.79	1.26
Japanese fir (*Abies firma*)	Trace	0.89	1.32
Japanese cedar (*Cryptomeria japonica*)	Trace	0.86	1.31
GROUND LIGNIN			
Japanese birch (*Betula platyphylla*)	0.53	0.82	0.32
LIGNOPHENOL DERIVATIVE			
Japanese birch (*Betula platyphylla*)	Trace	0.80	1.51
Japanese oak (*Quercus mongolica*)	Trace	0.88	1.51
Apitong (*Dipterocarpus grandiflorus*)	Trace	0.91	1.58

FIG.15

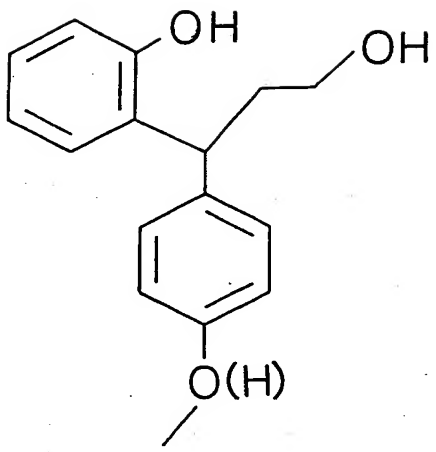


FIG.16

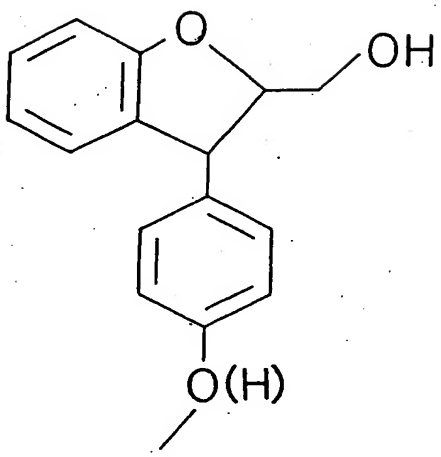


FIG.17

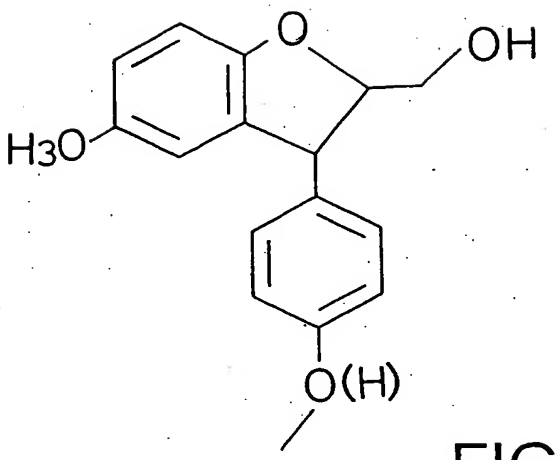


FIG.18

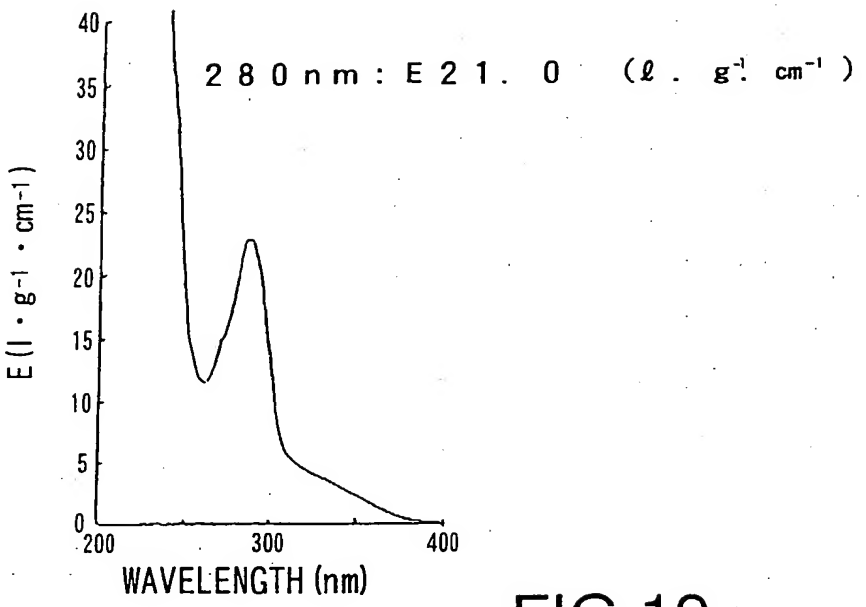

280nm : E 21. 0 (ℓ . g⁻¹. cm⁻¹)
E(l・g⁻¹・cm⁻¹)
40
35
30
25
20
15
10
5
0
200
300
400
WAVELENGTH (nm)

FIG.19

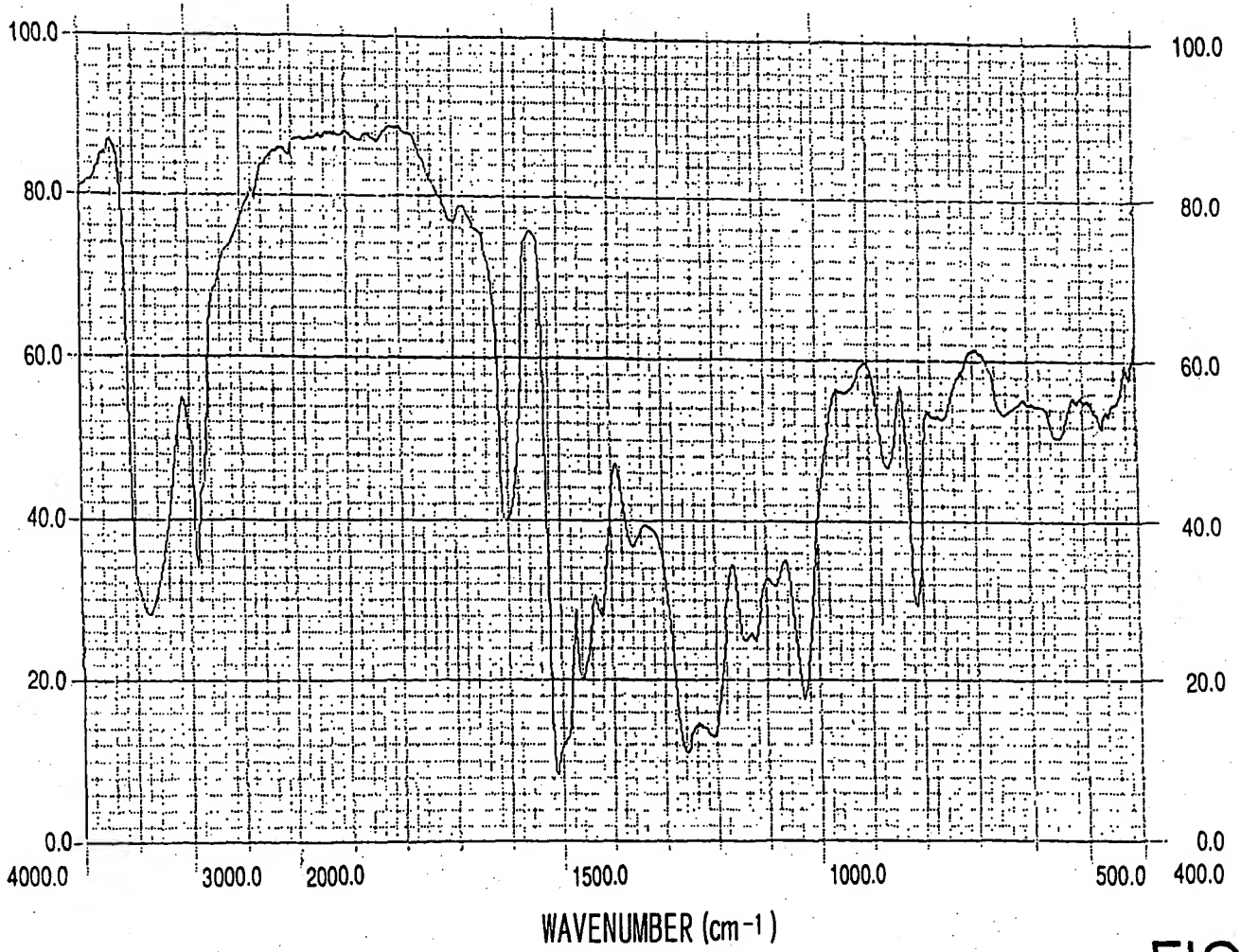

100.0
80.0
60.0
40.0
20.0
0.0
4000.0
3000.0
2000.0
1500.0
1000.0
500.0
400.0
WAVENUMBER (cm-1)

FIG.20

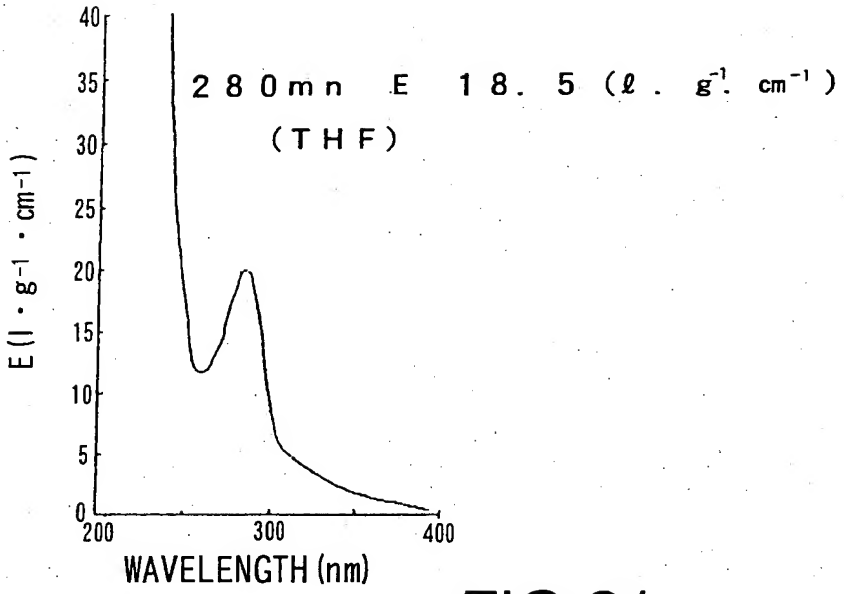

280mn E 18.5 (ℓ. g⁻¹. cm⁻¹)
(THF)
E(l・g⁻¹・cm⁻¹)
40
35
30
25
20
15
10
5
0
200
300
400
WAVELENGTH (nm)

FIG.21

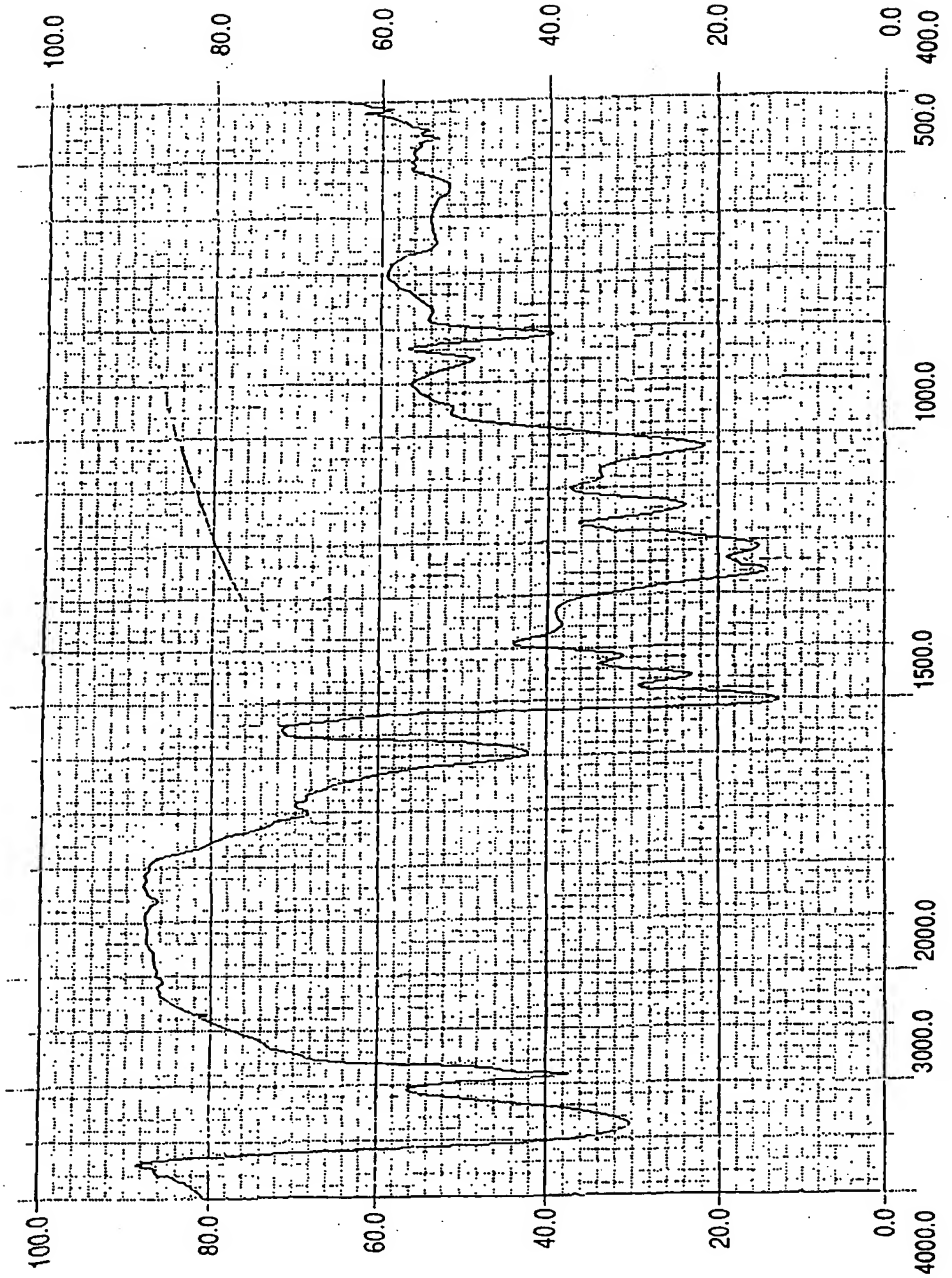

100.0
80.0
60.0
40.0
20.0
0.0
4000.0
3000.0
2000.0
1500.0
1000.0
500.0
400.0
WAVENUMBER (cm-1)

FIG.22

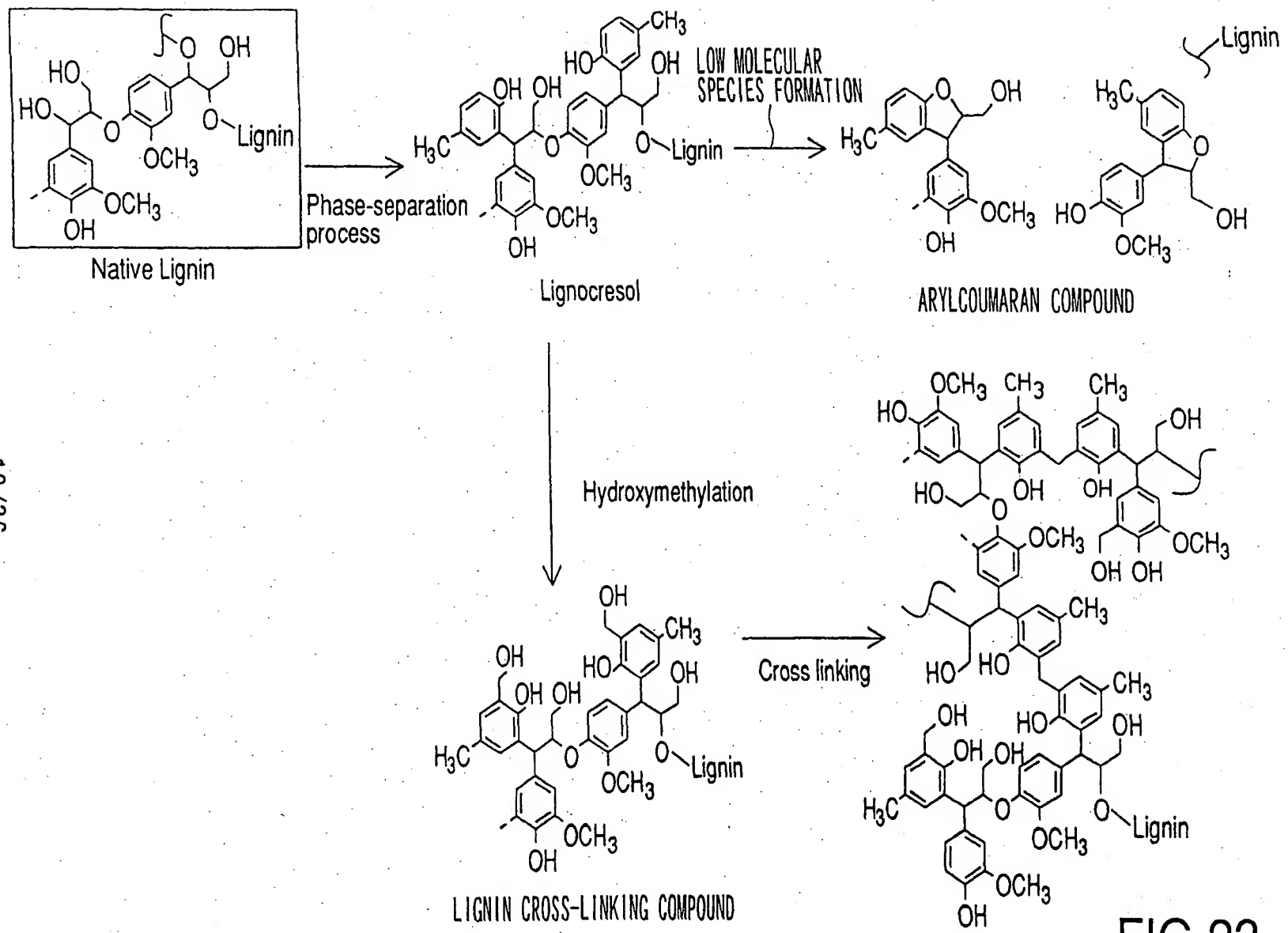

Native Lignin
Phase-separation process
Lignocresol
LOW MOLECULAR SPECIES FORMATION
ARYLCOUMARAN COMPOUND
Hydroxymethylation
LIGNIN CROSS-LINKING COMPOUND
Cross linking
Lignin

FIG.23

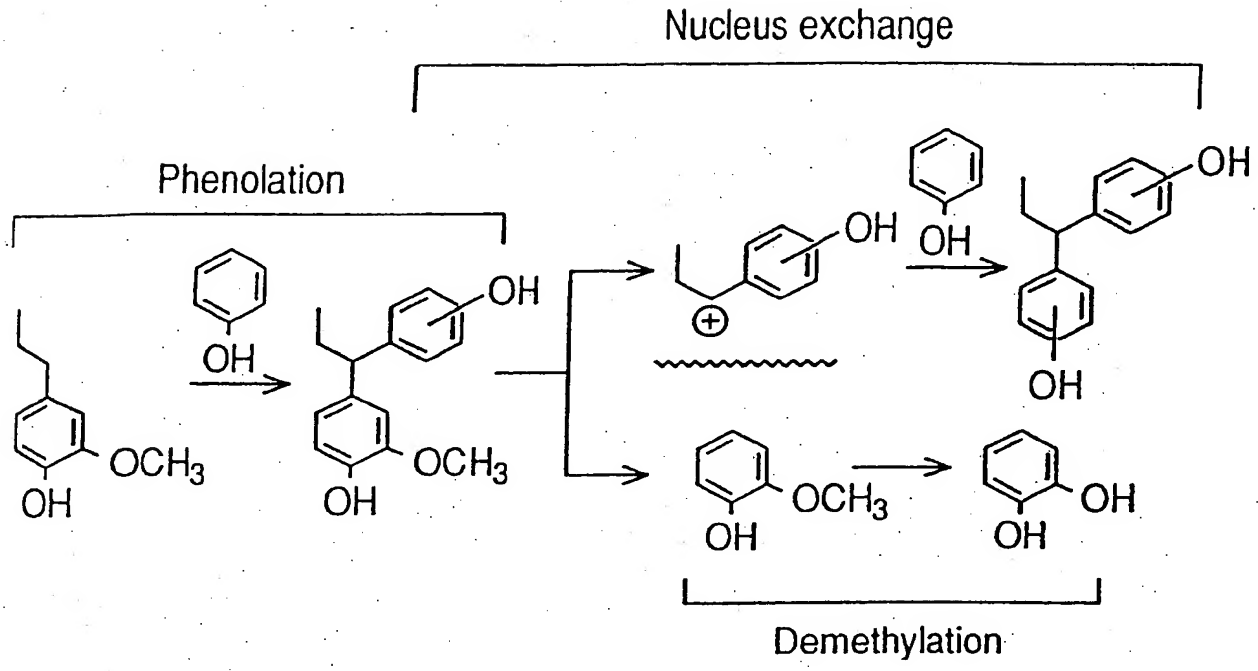

Nucleus exchange
Phenolation
OH
OCH3
OH
OH
OCH3
OH
OH
OH
OH
OCH3
OH
OH
OH
Demethylation

FIG.24

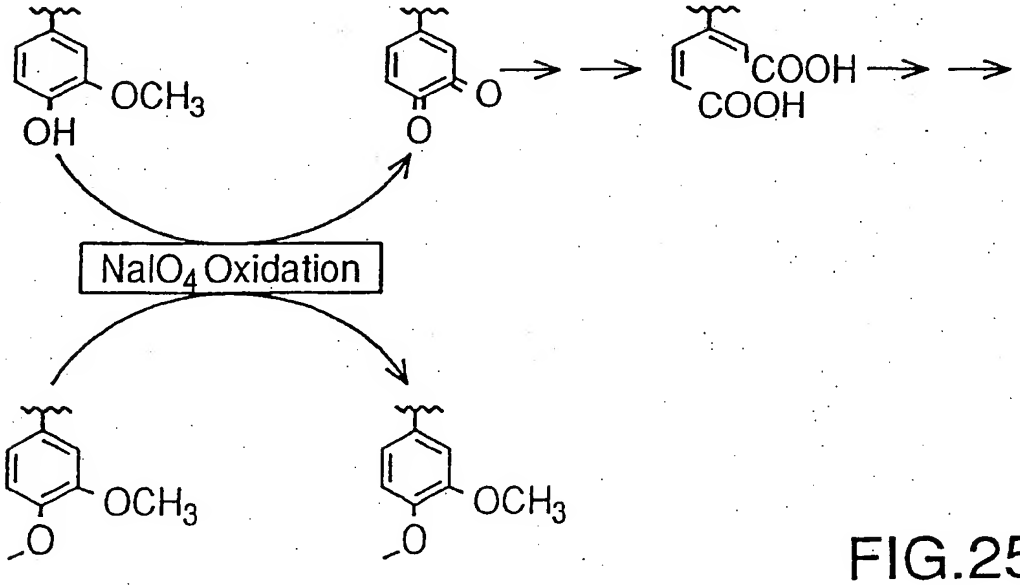

OCH3
OH
O
O
COOH
COOH
NaIO4 Oxidation
OCH3
O
OCH3
O

FIG.25

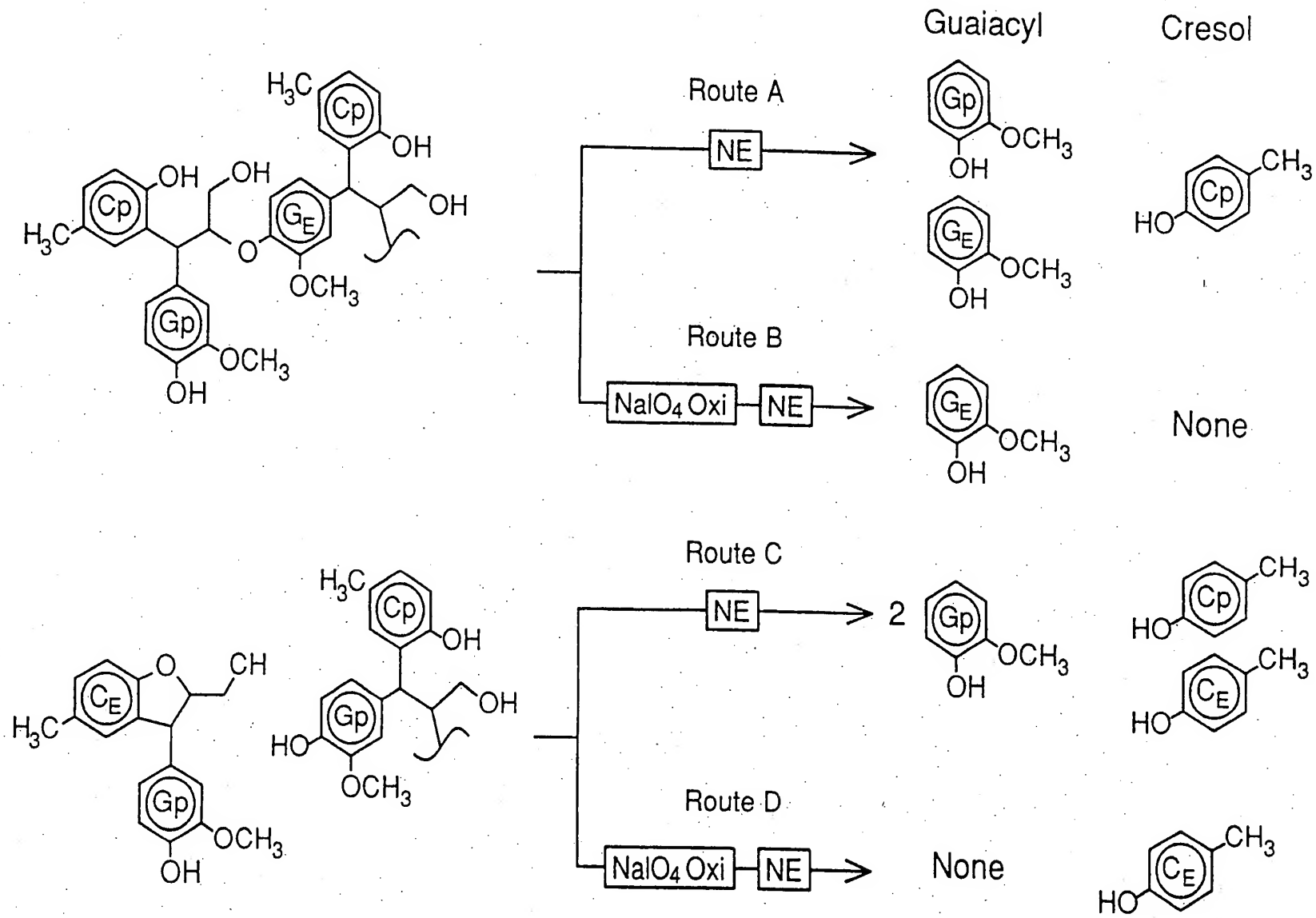

Guaiacyl
Cresol
Route A
NE
Route B
NaIO4 Oxi
NE
None
Route C
NE
2
Route D
NaIO4 Oxi
NE
None

FIG.26

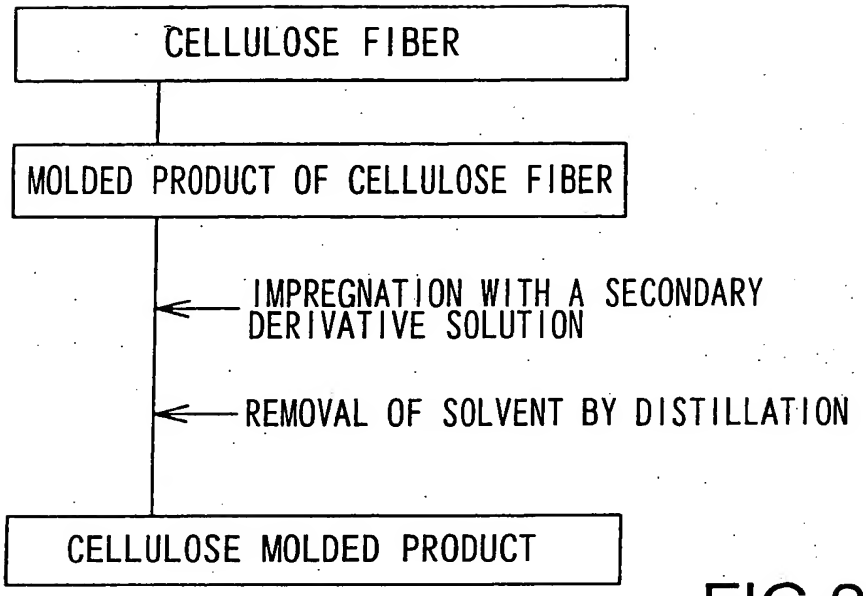

CELLULOSE FIBER
MOLDED PRODUCT OF CELLULOSE FIBER
IMPREGNATION WITH A SECONDARY DERIVATIVE SOLUTION
REMOVAL OF SOLVENT BY DISTILLATION
CELLULOSE MOLDED PRODUCT

FIG.27

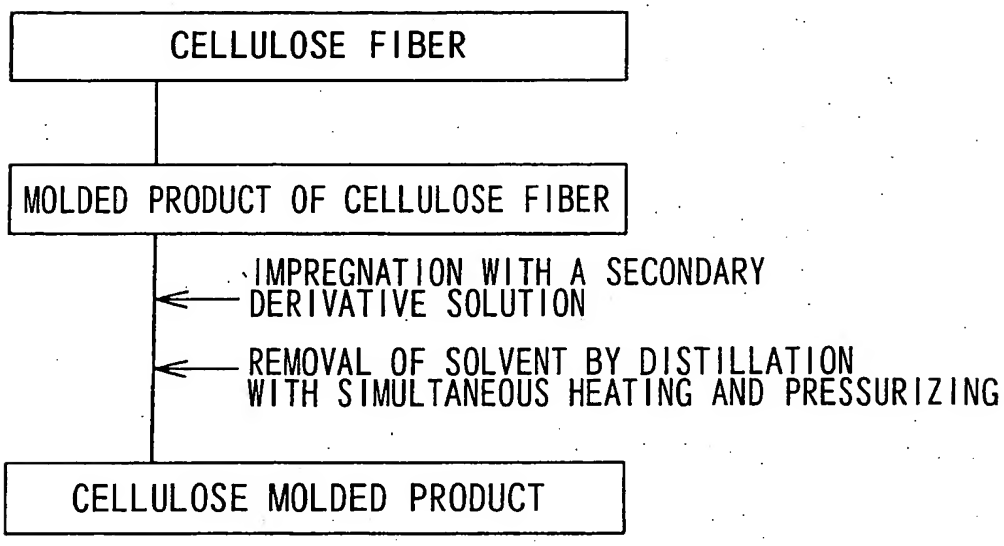

CELLULOSE FIBER
MOLDED PRODUCT OF CELLULOSE FIBER
IMPREGNATION WITH A SECONDARY DERIVATIVE SOLUTION
REMOVAL OF SOLVENT BY DISTILLATION WITH SIMULTANEOUS HEATING AND PRESSURIZING
CELLULOSE MOLDED PRODUCT

FIG.28

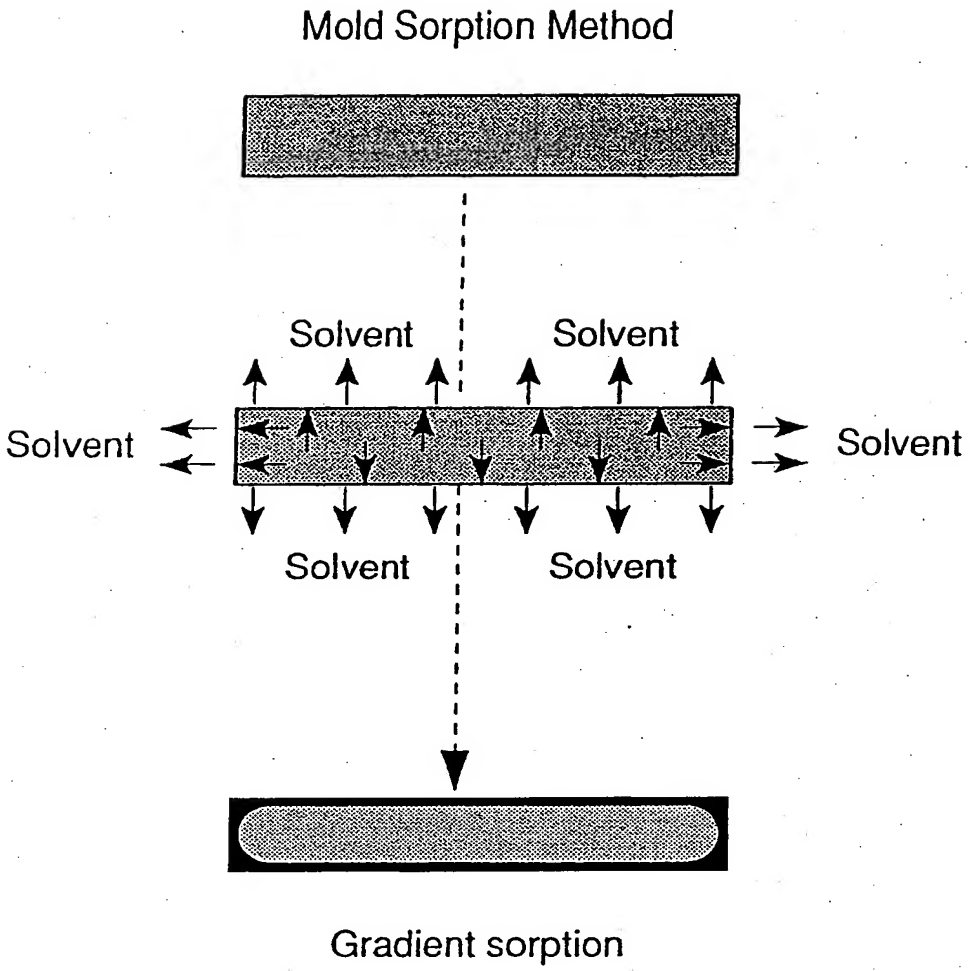

Mold Sorption Method
Solvent
Solvent
Solvent
Solvent
Solvent
Solvent
Gradient sorption

FIG.29

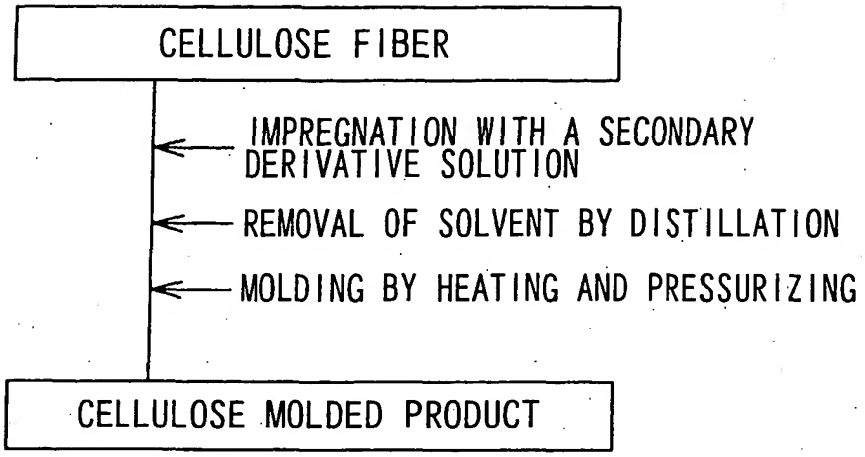

CELLULOSE FIBER
IMPREGNATION WITH A SECONDARY DERIVATIVE SOLUTION
REMOVAL OF SOLVENT BY DISTILLATION
MOLDING BY HEATING AND PRESSURIZING
CELLULOSE MOLDED PRODUCT

FIG.30

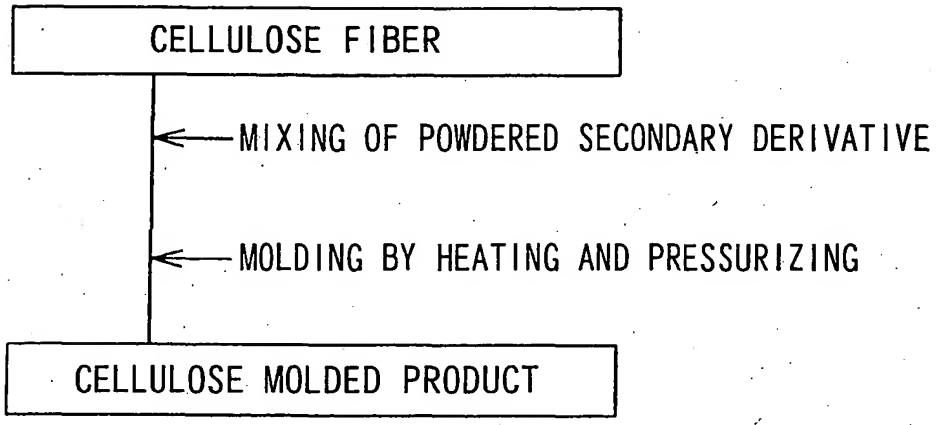

CELLULOSE FIBER
MIXING OF POWDERED SECONDARY DERIVATIVE
MOLDING BY HEATING AND PRESSURIZING
CELLULOSE MOLDED PRODUCT

FIG.31

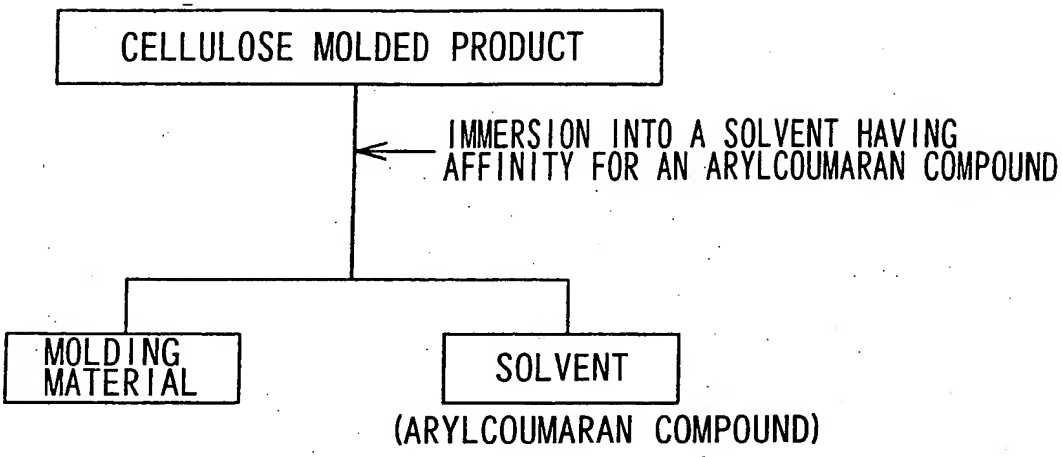

CELLULOSE MOLDED PRODUCT
IMMERSION INTO A SOLVENT HAVING AFFINITY FOR AN ARYLCOUMARAN COMPOUND
MOLDING MATERIAL
SOLVENT
(ARYLCOUMARAN COMPOUND)

FIG.32

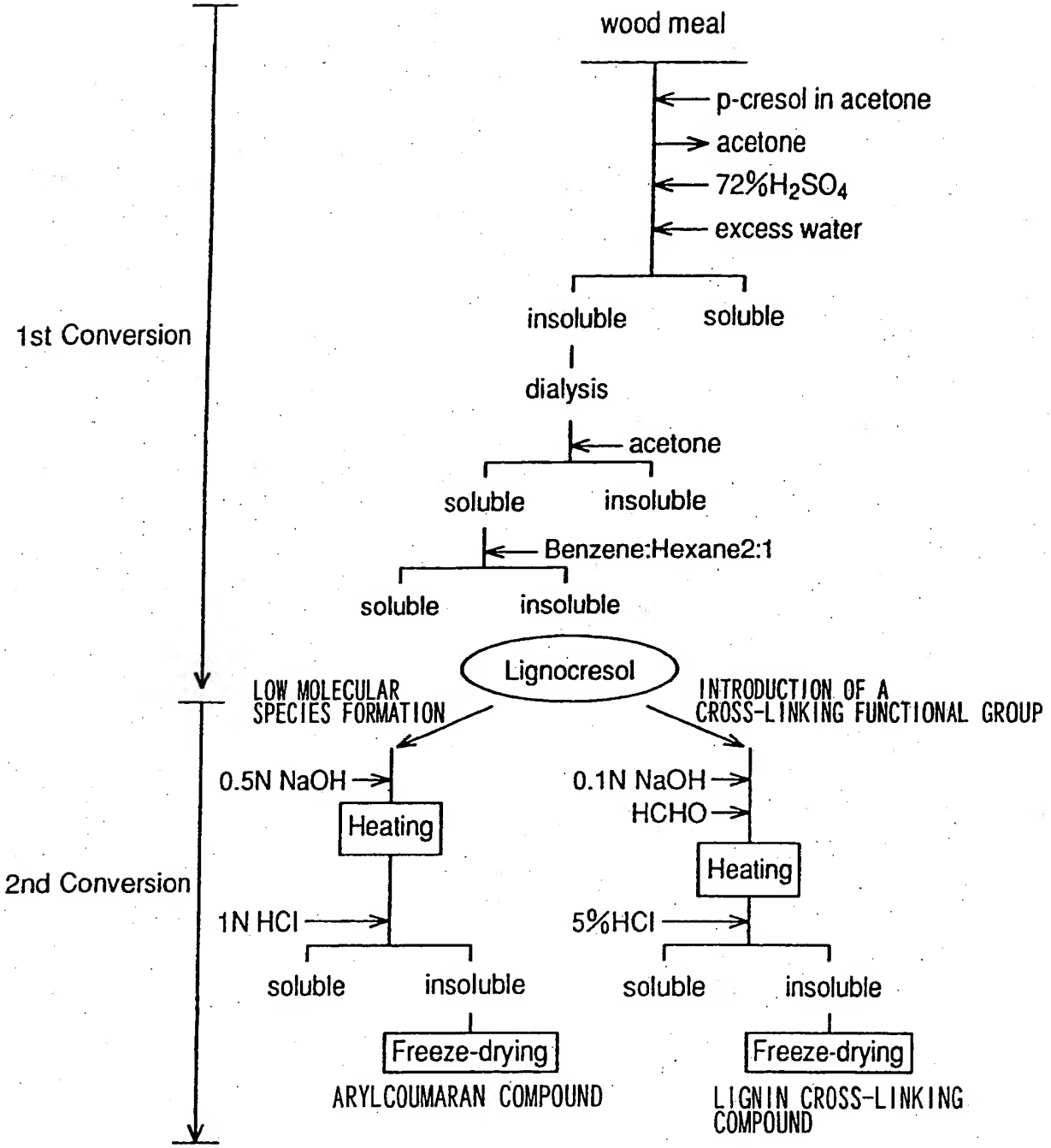

wood meal
p-cresol in acetone
acetone
72%H_2SO_4
excess water
insoluble
soluble
1st Conversion
dialysis
acetone
soluble
insoluble
Benzene:Hexane2:1
soluble
insoluble
Lignocresol
LOW MOLECULAR SPECIES FORMATION
INTRODUCTION OF A CROSS-LINKING FUNCTIONAL GROUP
0.5N NaOH
Heating
0.1N NaOH
HCHO
Heating
2nd Conversion
1N HCl
5%HCl
soluble
insoluble
soluble
insoluble
Freeze-drying
Freeze-drying
ARYLCOUMARAN COMPOUND
LIGNIN CROSS-LINKING COMPOUND

FIG.33

SAMPLE	YIELD(%)	AVERAGE MOLECULAR WEIGHT			AMOUNT OF INTRODUCED CRESOL	
		$\overline{M}w$	$\overline{M}n$	$\overline{M}w/\overline{M}n$	Wt%	mol/C9
LIGNOCRESOL	—	8355	2737	3.053	26.70	0.68
ARYLCOUMARAN COMPOUND	81.07	1261	576	2.190	24.41	0.60

FIG.34

SAMPLE	HYDROXYL GROUP (mol/C9)				FREQUENCY OF PHENOLIC RINGS	
	Phenolic		Aliphatic		Guaiacyl	Cresol
	Wt%	mol/C9	Wt%	mol/C9	(% of total guaiacyl)	(% of total cresol)
LIGNOCRESOL	9.94	1.60	6.21	1.00	46.04	81.14
ARYLCOUMARAN COMPOUND	9.75	1.51	7.68	1.19	67.09	67.83

FIG.35

SAMPLE	YIELD(%)	AVERAGE MOLECULAR WEIGHT			AMOUNT OF INTRODUCED CRESOL	
		$\overline{M}w$	$\overline{M}n$	$\overline{M}w / \overline{M}n$	Wt%	mol/C9
LIGNOCRESOL	—	10691	3260	3.279	13.62	0.30
LIGNIN CROSS-LINKING COMPOUND	91.58	2894	919	3.149	13.76	0.30

FIG.36

SAMPLE	HYDROXYL GROUP (mol/C9)				HYDROXYMETHYL GROUP (mol/C9)	
	Phenolic		Aliphatic			
	Wt%	mol/C9	Wt%	mol/C9	Wt%	mol/C9
LIGNIN CROSS-LINKING COMPOUND	7.75	1.06	10.55	1.44	6.90	0.56

FIG.37

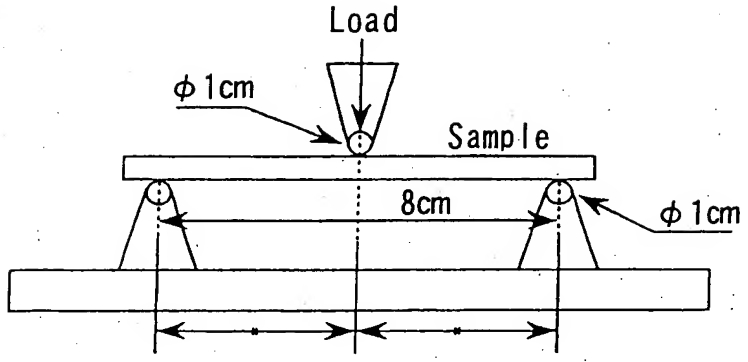
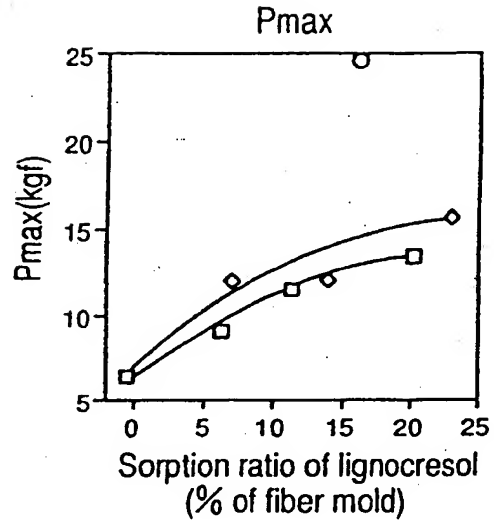


FIG.38

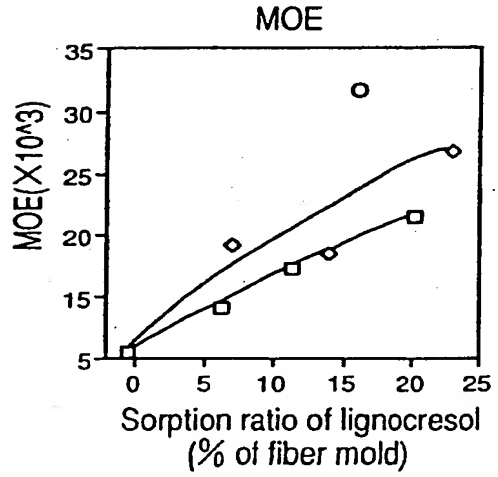


◻ Original lignocresol

◇ ARYLCOUMARAN COMPOUND

○ LIGNIN CROSS-LINKING COMPOUND

FIG.39 (a)

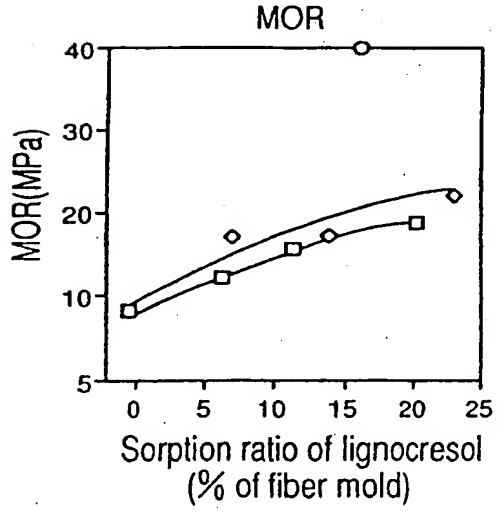


◻ Original lignocresol

◇ ARYLCOUMARAN COMPOUND

○ LIGNIN CROSS-LINKING COMPOUND

FIG.39 (b)

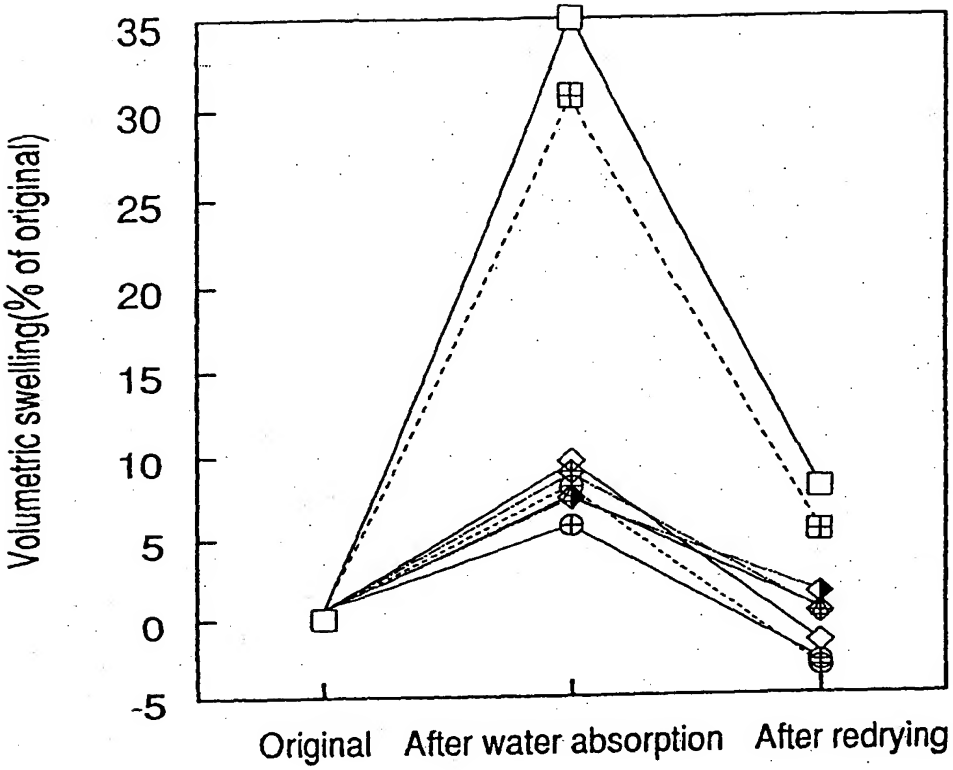


◻ Original lignocresol

◇ ARYLCOUMARAN COMPOUND

○ LIGNIN CROSS-LINKING COMPOUND

FIG.39 (c)


35
30
25
20
15
10
5
0
-5
Volumetric swelling(% of original)
Original
After water absorption
After redrying

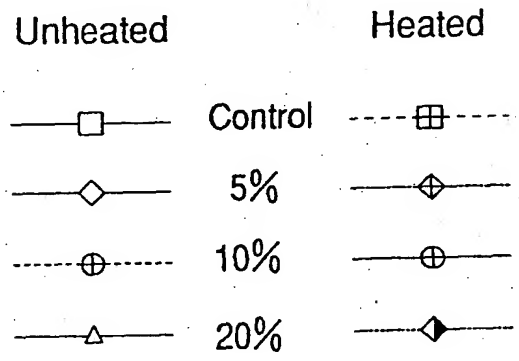
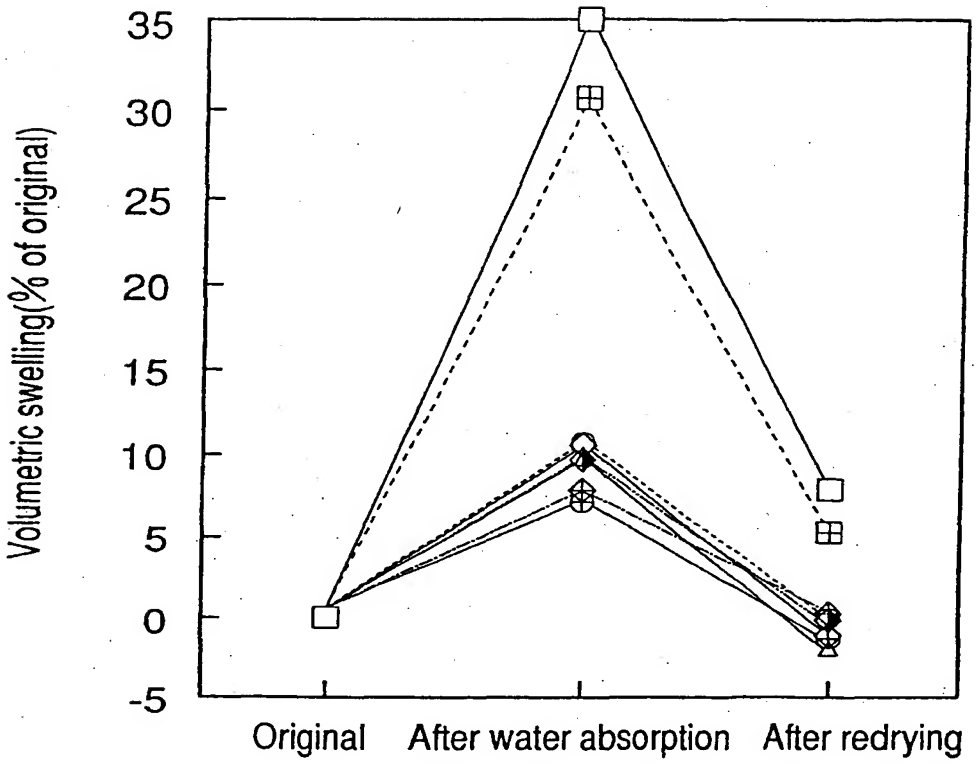

Unheated
Heated
Control
5%
10%
20%

FIG.40


Volumetric swelling(% of original)
35
30
25
20
15
10
5
0
-5
Original
After water absorption
After redrying

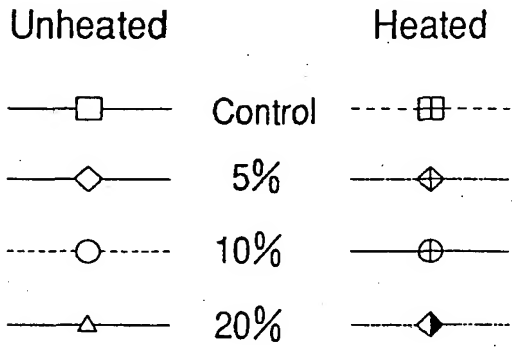
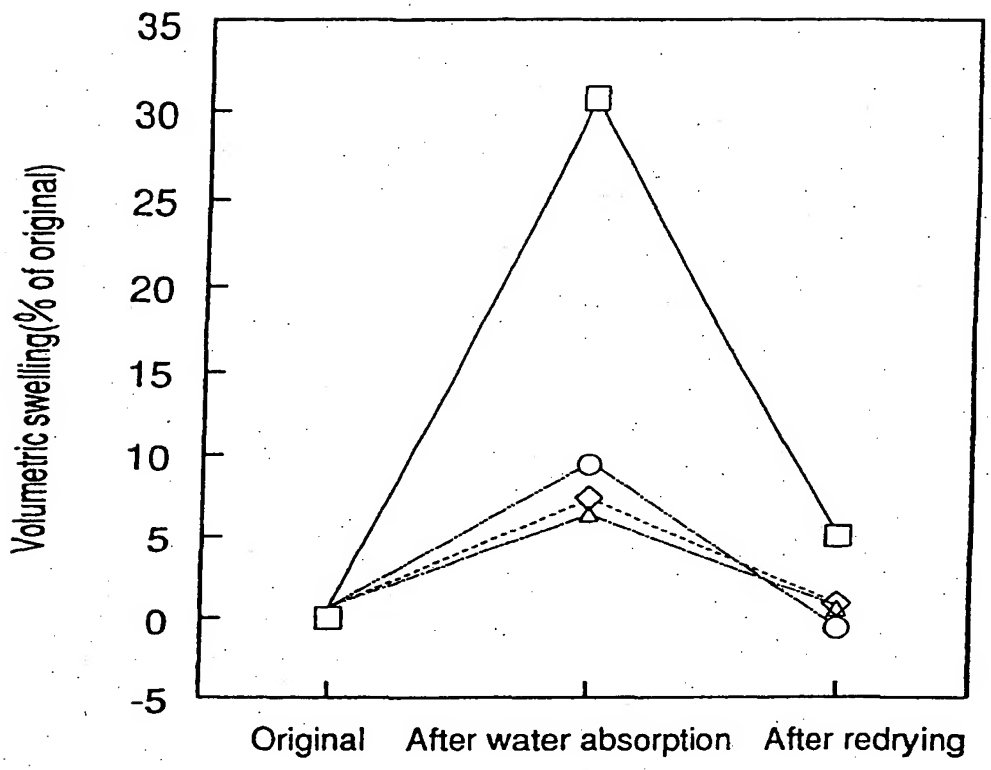

Unheated
Heated
Control
5%
10%
20%

FIG.41



CONTROL

LIGNOCRESOL

ARYLCOUMARAN COMPOUND

LIGNIN CROSS-LINKING COMPOUND

FIG.42

SAMPLE	SPECIFIC GRAVITY	WATER ABSORPTION *1	VOLUMETRIC INCREASE *2	
			AFTER WATER ABSORPTION	AFTER DRYING
CONTROL	0.475	167.88	30.52	5.22
LIGNOCRESOL	0.557	15.69	7.43	1.01
ARYLCOUMARAN COMPOUND	0.559	15.64	9.36	-0.51
LIGNIN CROSS-LINKING COMPOUND	0.596	9.34	6.55	0.77

* 1 : % RELATIVE TO WEIGHT BEFORE WATER ABSORPTION
* 2 : % RELATIVE TO VOLUME BEFORE WATER ABSORPTION

FIG.43

RECOVERY RATE OF A LIGNIN DERIVATIVE FROM A MOLDED PRODUCT
(% RELATIVE TO WEIGHT OF AN ATTACHED LIGNIN DERIVATIVE)

SAMPLE	UNHEATED	HEATED
LIGNOCRESOL	99.28	94.10
ARYLCOUMARAN COMPOUND	100.00	100.00
LIGNIN CROSS-LINKING COMPOUND	——	Trace

FIG.44